"Most days it's like herding cats," I joked with Mr. Willems at the end of a long day of tutoring. For the last three months I had been working with Chris Willems, a biology teacher at a New Haven high school, as a science mentor. My primary job was to talk to students about research projects they would like to undertake and submit to the local science fair and I was starting to appreciate how difficult a task this was. Although the students were engaging and fun to work with, I did not think they viewed research as much of a priority over whatever plans they had that weekend. The truth is that I can appreciate how abstract, disconnected, and unimportant science can seem to a teenager. In spite of now being enrolled in a PhD program, I didn't much care for science when I was in high school. At the time, it was hard to appreciate why all the facts I was being taught even mattered. We already knew what cells were, why bother memorizing organelles? I didn't come to an appreciation of science until my senior year of high school, when I took a class just like Mr. Willems's that completely changed my view of science.

That class at my high school focused on getting students into labs at the University of Arizona where they could undertake research projects in an area of their interest. I began working with a professor from the University on a project that compared the effectiveness of various media in growing diverse samples of oligotrophic bacteria. I was immediately captivated by the sheer amount we do not know about bacteria and how they grow. The world of research was sharply contrasted with the picture of science I had been given throughout high school. The disconnect I experienced between science classes and scientific research impressed upon me the importance of introducing young students to basic research. This realization later lead me to work with Mr. Willems tutoring high school students, but first I would go through a number of research opportunities in high school and college that taught me not only how to be a scientist but also a member of the scientific community.

For my research in high school, I was selected to give an oral presentation at the statewide Junior Science and Humanities Symposium in Arizona as well as a poster presentation at the Southern Arizona Science and Engineering Fair. From these presentations I was awarded $14,000 in scholarships, and was given the opportunity to present my research at the Intel International Science and Engineering Fair. The fair not only provided an indelible learning experience about project presentation but also a lesson on the social side of science, as I spent the week meeting and socializing with hundreds of other young aspiring scientists. These experiences made such an impression on me that I spent the next four years involved in research.

In my first semester at college, I was offered a paid position in a cancer-oriented mathematical modeling lab with Professor Richard Posner. I worked in this lab over the course of the next three years and with the help of a tuition scholarship, my efforts in this job paid for my undergraduate education. This research focused on modeling information processing in the epidermal growth factor receptor (EGFR) pathway. This pathway effects is an important target in cancer treatment, making it an attractive subject for predictive models. A complication with the EGFR pathway is that the protein network is so large that it cannot be simulated in any detail with conventional modeling techniques. By adopting a new method, my work demonstrated how such a large network could be modeled. This was my first introduction into the topic of information processing which has since become the focus of my career.

In addition to developing my scientific skills, I was particularly interested in stimulating collaboration and exchanging ideas by presenting my research to the broader community. To this end, I presented 5 posters and abstracts during my three-year undergraduate career[2-6] culminating in a first-author publication[1]. My work required bringing together experts in modeling, mathematics, biochemistry, and cell biology in order to develop and specify a fully complex

model of EGFR signaling. My presentations resulted in many discussions and generated long-standing collaborations attributed in the manuscript resulting from this work.

At the end of my undergraduate career, I participated in the Helios Scholars Program at Translational Genomics Research Institute (TGen) in Phoenix, Arizona. The Helios Scholars Program gives undergraduates the opportunity to work one-on-one with researchers over the summer to perform translational research. Working at TGen introduced me to the translational aspect of research, and showed me how lab work is incorporated into clinical studies. The work I performed there was presented as an oral presentation at the Helios Scholars symposium and received the 2nd place award in the internship.

The epithelial research group at the Ludwig Institute for Cancer Research (LICR) in Melbourne, Australia noticed the research I performed on the EGFR model while in college. I was offered a job on the condition that I first complete my Bachelor's degree. Excited by this proposition, I graduated a year early from college so that I could spend that time working as a research assistant at LICR. Once in Melbourne, I began building a model of the Notch signaling pathway and experimentally measuring some of its parameters. This research allowed me to combine traditional experimental work with a computational approach. I was interested in how the pro-Notch1 stem cell marker protein Musashi-1 affected Notch signaling both in intercellular as well as intracellular signaling. I presented this research at the 2012 Systems Biology of Colonic Crypts symposium in Melbourne, Australia[8].

In addition to the research I performed, working in Australia was a great opportunity to understand the international aspect of science. During my stay, the Strategic Review of Health and Medical Research in Australia panel was established. This panel was created in response to the Australian government's proposal to reduce spending for medical research in 2011. The panel's work focused on addressing how to restructure government-funded research in Australia to better support young principle investigators (PI) and to reduce the burden of grant writing, which detracts from research productivity. I organized researchers both at LICR and the neighboring Walter and Eliza Hall Institution to attend the public meetings and voice our opinions. In particular, we wanted to emphasize the need for grants of longer duration and more opportunities for grant submission, so that if a research proposal doesn't get funded, the PI will not have to wait for a year to submit again. Participating in this discussion demonstrated to me how important and complicated the fiscal environment surrounding science is.

During my stay in Australia I decided I wanted to pursue a PhD in neuroscience. My work over the past four years both in Australia and in my undergraduate career had focused on information processing in protein networks. Information processing interests me because it represents a difficult question to answer: how do you extract meaningful information from a complex environment? In this respect, there is no system more complicated or elegant than the brain. I am fundamentally interested in what algorithms the brain uses to extract information and how those algorithms are implemented through the circuitry of neurons.

Now a PhD student at Yale University, I work with Professor Damon Clark. Dr. Clark's research combines neuroscience and mathematical modeling to define the segregation of motion information into ON and OFF pathways in the *Drosophila* visual system. Given my research in computational biology and my interest in defining neural circuitry, the environment of the Clark lab seemed like a unique opportunity to apply my skills while learning new ways to investigate biological questions. I began my rotation by building five walking tethered fly rigs. In each rig, the fly stands on a ball in the middle of three screens, which allow for complete control of its visual field. The fly remains in place while walking on the ball in response to visual stimuli. The

fly's movements are recorded from the motion of the ball, providing a measurement of the fly's visual percept. Using this rig I have begun investigating how flies combine visual information between their two eyes, and how they integrate information to make decisions.

During my first year in graduate school, I participated in several community outreach programs, served as a judge at the two local science fairs, and acted as a mentor for high school students. Every year, my graduate program organizes Brain Day, an event tailored for both middle and high school students who visit Yale to learn about neuroscience. I volunteered to use imaging data I had generated in lab to create a display to explain how neurons use electricity to send signals. I also regularly engage in outreach to local high schools where we put on small demonstrations for classes. These familiarize the students with the morphological differences not only among brains of different species, but also among the various neural cell types.

Through these outreach programs, I learned that Chris Willems was teaching a high school research class just like the one that had introduced me to research science, but at a New Haven high-poverty school. I was ecstatic, albeit a little nervous, about mentoring high school students through the exact process that had made science such a big part of my life. My job was not to provide ideas, but to help them understand the basics of the scientific method, to which many of the students had not been exposed. Over the course of a few months, the students' projects began to take shape. Despite this being a new experience for many of the students, they ended up creating consistent procedures and testing reasoned hypotheses. The last requirement of the class was to present at the local science fair and I am proud to report that my students took home the 1st and 2nd place prizes in physical science.

In addition to mentoring, I was a judge for both the local New Haven Science Fair – although I did not judge my students' projects– as well as for the Southern Connecticut Science and Engineering Fair (SCISEF), produced by Intel. The contrast between these two events was striking. The local fair consisted mainly of self-initiated projects while SCISEF attracted students who had worked in a laboratory at a research university. The disparity between these two fairs demonstrates the necessity of emergent curricula like Mr. Willems's, which provides mentorship for students interested in a STEM degree. In many areas of New Haven students have no exposure to the application of the scientific method, and without these programs students will not receive the support necessary to succeed given the challenges of higher education.

My numerous experiences have taught me how to conduct rigorous research, contribute to the scientific community, and benefit the wider community of non-scientists. I have been engaged in research since high school and I am dedicated to my study of information processing in biological systems. My experiences in publishing and presenting research[1-8], as well as engaging in public discourse about funding, have taught me the value of communication in science. I was introduced to research through outreach programs and this has inspired me to support science in the local community by volunteering at local science fairs and New Haven public schools. I believe this kind of outreach is fundamentally important to promoting science and I look forward to continuing my involvement in the New Haven community.

Publications and Poster Abstracts

1. **Creamer MS** *et al*. BMC Syst Biol 6, 107 (2012).
2. Colvin J, Naik N, **Creamer MS**, *et al*. Q-bio meeting, Santa Fe, NM 2009.
3. Posner RG, Colvin J, **Creamer MS**, *et al*. NCI Translational Medicine Meeting, Washington, DC 2009.
4. Naik N, Colvin J, Mcdonough W, Berens M, **Creamer M**, *et al*. TGen Annual Retreat, Phoenix, AZ 2009.
5. **Creamer MS**, *et al*. TGen Annual Retreat, Phoenix, AZ 2010.
6. **Creamer MS**, *et al*. Helios Scholar Symposium, Phoenix, AZ 2011.
7. Stites EC, **Creamer MS**, *et al*. 56th Annual Meeting of the Biophysical Society, San Diego, CA, Feb 2012.
8. **Creamer MS**, *et al*. Systems Biology of Colonic Crypts, Melbourne, Australia 2012.